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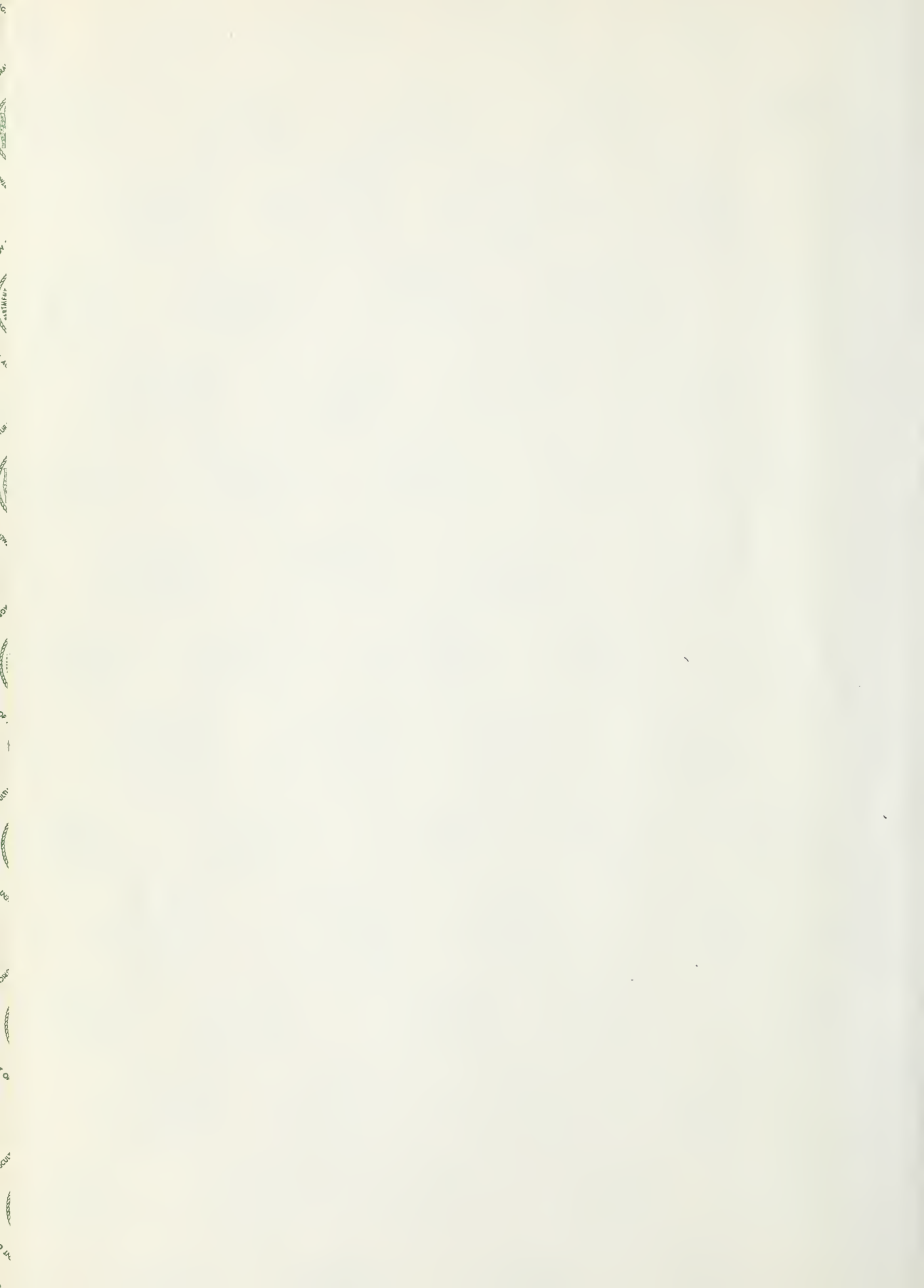
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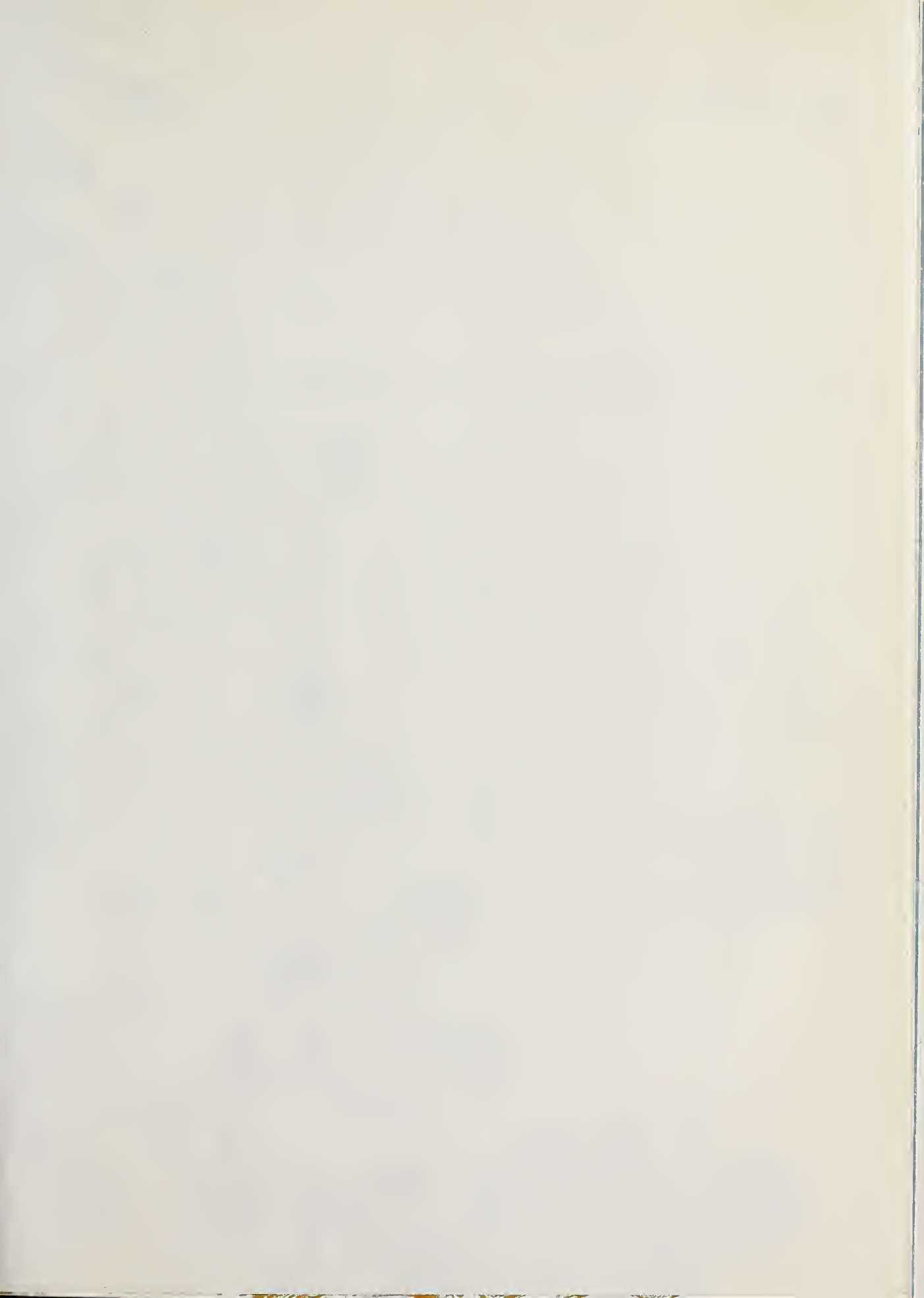
















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USDA Forest Service  
General Technical Report RM-36  
April 1977

120

## Fungal Parasites of Dwarf Mistletoes

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## Abstract

At least eight fungi are known to parasitize dwarf mistletoe shoots in North America. Three of these (*Colletotrichum gloeosporioides*, *Cylindrocarpon gillii*, and *Wallrothiella arceuthobii*) are common and occur on most of the dwarf mistletoes in the western United States. *Pestalotia heterocornis* and *Cylindrocarpon* sp. are reported for the first time as dwarf mistletoe parasites. The other three fungi (*Pestalotia maculiformans*, *Metasphaeria wheeleri*, and *Alternaria alternata*) are rare or local as mistletoe parasites. Although some of these fungi may decimate dwarf mistletoe shoots and fruits in certain localities in certain years, their overall role in limiting dwarf mistletoes seems to be minor.

**Keywords:** *Colletotrichum gloeosporioides*, *Cylindrocarpon gillii*, *Wallrothiella arceuthobii*, hyperparasites, biological control.

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## **Fungal Parasites of Dwarf Mistletoes**

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## **Acknowledgments**

We thank Don Knutson, USDA Forest Service, Corvallis, Oregon for providing collections and locations for fungi in the Pacific Northwest. Also, we gratefully acknowledge the assistance of Dr. E. Guba in identifying *Pestalotia heterocornis*.

<sup>1</sup>Central headquarters maintained at Fort Collins in cooperation with Colorado State University.



The three most common fungus parasites of dwarf mistletoe:  
*Coletotrichum gloeosporioides* on *Arceuthobium abietinum* (upper left): the tips of the mistletoe shoots have been killed by the fungus.  
*Cylindrocarpon gillii* on *Arceuthobium campylopodum* (upper right): fruiting bodies showing masses of white spores; shoots are girdled and killed distal to the infection.  
*Wallrothiella arceuthobii* on *Arceuthobium douglasii* (lower): nearly every mistletoe fruit is parasitized by the fungus (black tips). Only a few normal (nonparasitized) fruits remain.



# Fungal Parasites of Dwarf Mistletoes

Frank G. Hawksworth, Ed F. Wicker and Robert F. Scharpf

## INTRODUCTION

The dwarf mistletoes (*Arceuthobium* spp.) are widespread parasites of conifers in western North America (Hawksworth and Wiens 1972). This Paper summarizes the literature and our observations on distribution of parasitic fungi associated with dwarf mistletoes and discusses their potential as biological control agents. It is restricted to fungi that parasitize the aerial shoots of dwarf mistletoes, and does not consider fungi that may be associated with dwarf mistletoe root systems within the host, such as *Cytospora abietis* on true firs (Scharpf 1969). Information on several such dwarf mistletoe "canker fungi" is summarized by Hawksworth (1972). The area considered in this Paper includes the western United States, Mexico, and the Caribbean.

Kuijt (1963) summarized the distribution of two fungal hyperparasites of *Arceuthobium* in western Canada: *Wallrothiella arceuthobii* and *Cylindrocarpon gillii*. *Colletotrichum gloeosporioides* was not recognized by Kuijt, and several of his reports of *C. gillii* are based on misidentification of *C. gloeosporioides* (Muir 1967). Wicker and Shaw (1968) reported several fungal parasites of dwarf mistletoes in the Pacific Northwest.

## THE FUNGAL PARASITES

Eight fungal parasites of dwarf mistletoe shoots are presently known in North America (table 1), two of which are reported here for the first time. Only three—*Colletotrichum gloeosporioides*, *Cylindrocarpon gillii*, and *Wallrothiella arceuthobii*—are widely distributed; the others are known only from limited areas.

The host distribution of the three major fungi on the dwarf mistletoes of the western United States is given in table 2. Note that *Arceuthobium gillii*, which occurs in extreme southern Arizona, is the only western dwarf mistletoe that has not been reported to have been parasitized by these fungi. Several other dwarf mistletoes occur in Mexico (Hawksworth and Wiens 1972), but these fungi have been found there only on species that also occur in the United States: *A. blumeri*, *A. divaricatum*, and *A. douglasii*. The three primary fungi are known in all western States where dwarf mistletoes occur, except Alaska. Their distribution in Mexico is poorly known; they have so far been collected in only four States. These three fungi also occur in four western Canadian Provinces: British Columbia, Alberta, Saskatchewan, and Manitoba (Kuijt 1963, Muir 1967).

Table 1.—Parasitic fungi found on shoots of *Arceuthobium* spp.

Fungus	Locality	References
<i>Colletotrichum gloeosporioides</i> Penz. (Melanconiales)	Western U.S., Canada, and Mexico	Hawksworth et al. 1968; Muir 1973; Parmeter et al. 1959; Scharpf 1964; Wicker 1967; Wicker and Shaw 1968.
<i>Cylindrocarpon gillii</i> (Ellis) J. A. Muir ( <i>Septogloeum gillii</i> Ellis) (Melanconiales)	Western U.S., Canada, and Mexico	Ellis 1939, 1946; Gill 1935, 1952; Kuijt 1963; Mielke 1959; Muir 1973; Wicker and Shaw 1968.
<i>Cylindrocarpon</i> sp. (Melanconiales)	Southern Mexico	First reported in this paper.
<i>Wallrothiella arceuthobii</i> (Peck) Sacc. (Sphaeriales)	U.S., Canada, and Mexico	Dowding 1931; Hawksworth 1961; Kuijt 1963, 1969; Knutson and Hutchins 1974; Parker 1970; Peck 1875; Weir 1915; Wicker and Shaw 1968.
<i>Alternaria alternata</i> (Fr.) Keissler ( <i>A. tenuis</i> Nees.) (Moniliales)	Manitoba, Canada	Sutton 1973.
<i>Metasphaeria wheeleri</i> Linder (Sphaeriales)	California	Linder 1938.
<i>Pestalotia maculiformans</i> Guba & Zeller (Melanconiales)	Washington	Wicker and Shaw 1968.
<i>Pestalotia heterocornis</i> Guba (Melanconiales)	Dominican Republic	First reported in this paper.

Table 2.—Known hosts of the three major fungal parasites of dwarf mistletoes in the western United States.

<i>Arceuthobium</i>	<i>Colletotrichum gloeosporioides</i>	<i>Cylindrocarpon gillii</i>	<i>Wallrothiella arceuthobii</i>
<i>A. abietinum</i>			
f. sp. <i>concoloris</i>	X	X	—
f. sp. <i>magnificae</i>	X	X	—
<i>A. americanum</i>	X	X	X
<i>A. apachecum</i>	X	X	—
<i>A. blumeri</i>	—	X	—
<i>A. californicum</i>	X	X	—
<i>A. campylopodium</i>	X	X	—
<i>A. cyanocarpum</i>	—	X	—
<i>A. divaricatum</i>	X	X	—
<i>A. douglasii</i>	X	X	X
<i>A. gillii</i>			
subsp. <i>gillii</i>	—	—	—
<i>A. laricis</i>	X	X	—
<i>A. microcarpum</i>	X	X	—
<i>A. occidentale</i>	X	—	—
<i>A. tsugense</i>	X	X	—
<i>A. vaginatum</i>			
subsp. <i>cryptopodium</i>	—	—	X <sup>1</sup>

<sup>1</sup>Extremely rare.*Colletotrichum gloeosporioides*

This fungus was first reported on *Arceuthobium abietinum* in California by Parmeter et al. (1959), although Wicker and Shaw (1968) show that it was recognized by J. R. Weir (as "*Gloeosporium* sp.") in the Pacific Northwest prior to 1920. The fungus has been recorded on 12 of the 16 dwarf mistletoes in the western United States (table 2).

*C. gloeosporioides* is one of the most widely distributed of the dwarf mistletoe parasites (fig. 1). It is known from all western States except Nevada and Wyoming, and occurs in Baja California, Mexico (Hawksworth et al. 1968). There is a rather large gap in the known range of the fungus in the Great Basin area and from southern Colorado to western Montana (fig. 1). It seems likely the fungus is not really absent from this area, but simply has not been found due to a lack of intensive collecting of dwarf mistletoe parasites.

*C. gloeosporioides* infection first appears as a small brown to black necrotic lesion on the shoots, usually at the nodes. The lesions enlarge, coalesce, and cause die-back of the shoots (Parmeter et al. 1959, Wicker and Shaw 1968). Although shoots are the site of initial infection, the fungus can grow into the base of the shoot within the host tissue. In an area in California studied by Parmeter et al. (1959), about 80% of the *A. abietinum* shoots were affected by the fungus to some extent. Over half of the dwarf mistletoe plants

bore no shoots, apparently due largely to the fungus. Much lower levels of infection were found in several subsequent years. The fungus is apparently very sporadic and only builds up to high levels when weather conditions are favorable.

Wicker (1967) analyzed the effects of the fungus on *A. campylopodium* on ponderosa pine near Spangle, Washington and found that from 35% to 67% of the plants were diseased and 24% of the shoots were killed. Muir (1967) found *C. gloeosporioides* to be destructive to *A. americanum* in several localities in British Columbia and Alberta.

This fungus has several cultivars that differ in cultural characters. However, cross inoculations have shown no host specificity among these different cultivars (Scharpf 1964).

**Specimens examined:** see Appendix.

*Cylindrocarpon gillii*

This fungus was identified and discussed as *Fusarium campylopodii* sp. nov. in an unpublished manuscript by J. R. Weir before 1920 (Wicker and Shaw 1968). Gill (1935) was first to publish an account of the fungus. Ellis (1939) tentatively referred the fungus to the genus *Fusarium*, and later formally described it as *Septogloeum gillii* (Ellis 1946). Muir (1973) transferred it to the genus *Cylindrocarpon*. The fungus is now known to parasitize all but 3 of the 16 dwarf mistletoes in the western United States.

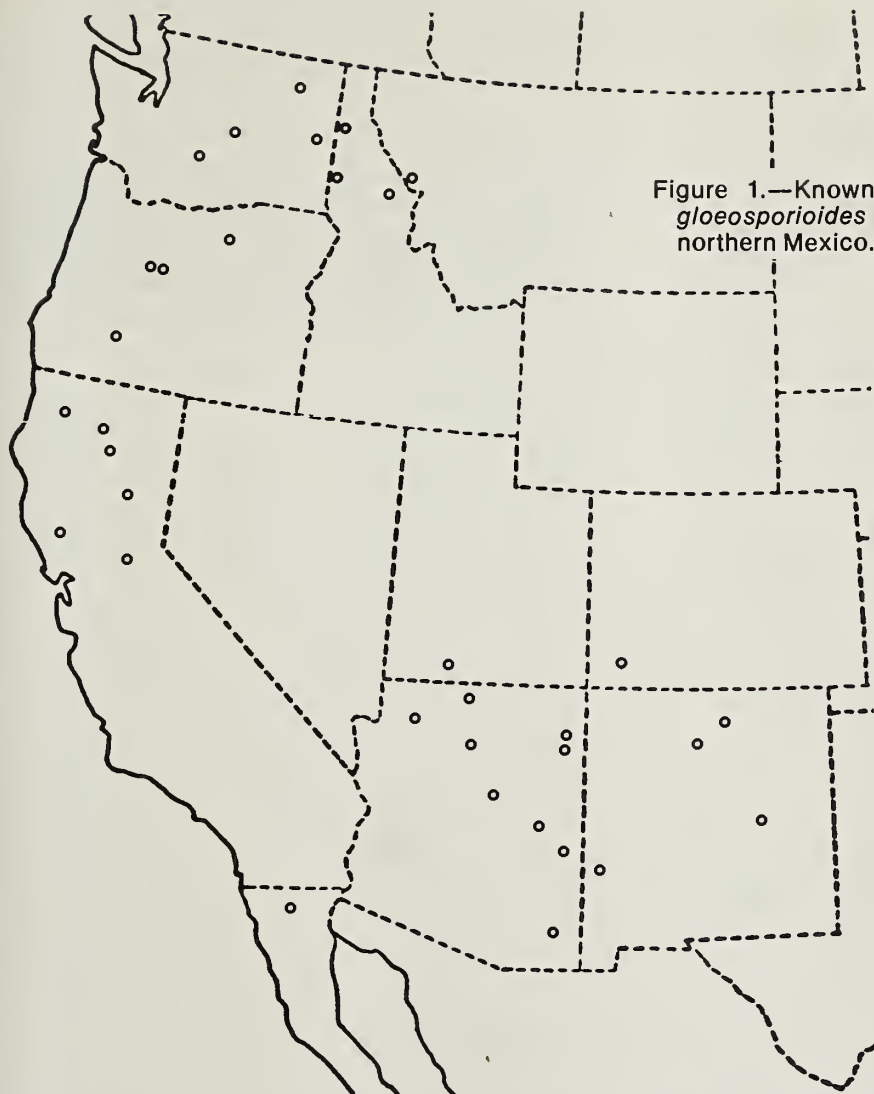


Figure 1.—Known distribution of *Colletotrichum gloeosporioides* in the western United States and northern Mexico.

(table 2). Hundreds of populations of *A. vaginatum* subsp. *cryptopodum* have been examined for the parasite, many where the fungus occurs on associated species, but all without success. Ellis (1946) was able to obtain infection of this dwarf mistletoe by wounding the shoots, but could not infect unwounded tissue.

*Cylindrocarpon gillii* is widespread on dwarf mistletoe from British Columbia and Alberta (Kuijt 1969), throughout the western United States (fig. 2), and into northern Mexico (Durango and Nuevo León). We have seen few collections of the fungus from Montana, Wyoming or Idaho but we suspect that intensive searches will reveal it is widely distributed in these areas also.

Early infection stages of *C. gillii* are characterized by small, yellowish-white lesions on the shoots. Lesions gradually enlarge, coalesce, and

erupt irregularly through the epidermis, disclosing conspicuous white spore masses. Portions of shoots or entire shoots distal to the point of infection are killed (Ellis 1946). The fungus sometimes parasitizes dwarf mistletoe fruits. Both pistillate and staminate plants are attacked. Ellis (1946) says the fungus is more frequent on pistillate plants, but Wicker and Shaw (1968) reported that the fungus showed no preference for either sex of dwarf mistletoe plants. The disease has been reported to exert a considerable degree of natural control over *Arceuthobium microcarpum* and *A. apachecum* (as *A. campylopodum* f. *cyanocarpum*) in Arizona (Ellis 1946) and in *A. tsugense* in Washington (Gill 1935).

Mielke's (1959) study of *Cylindrocarpon gillii* is apparently the only attempt to introduce a fungus into a new area to control a dwarf mistletoe. He inoculated isolates of the fungus from *Arceu-*

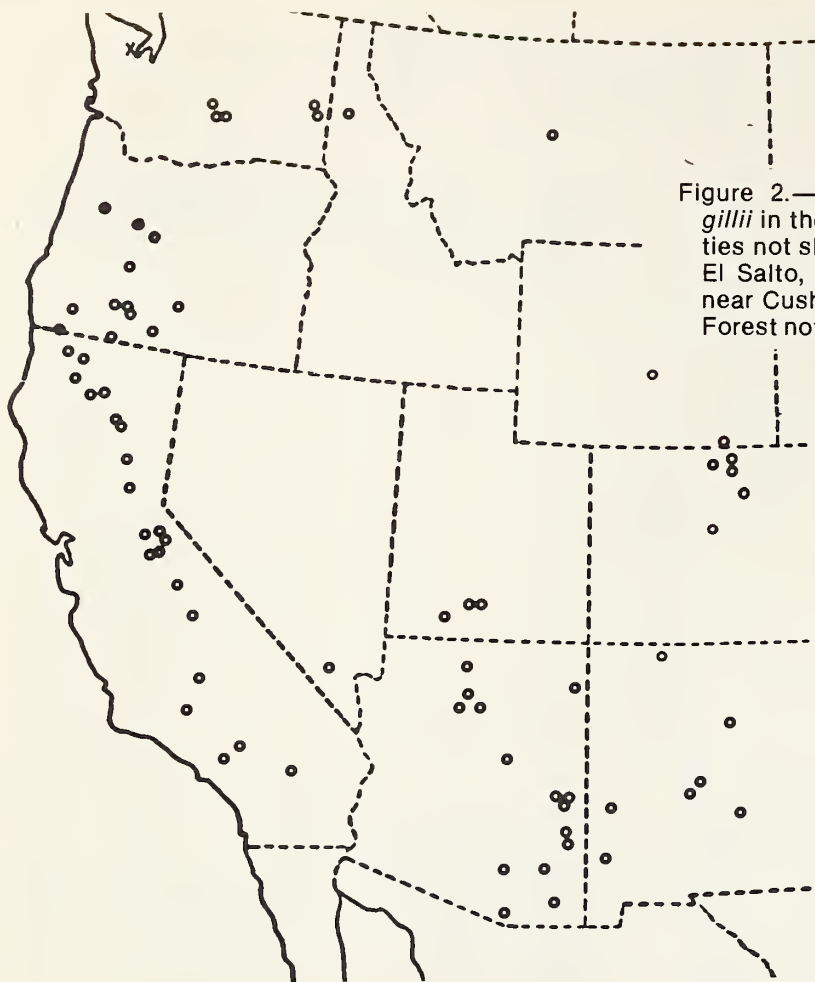


Figure 2.—Known distribution of *Cylindrocarpon gillii* in the western United States. Mexican localities not shown are Cerro Potosí, Nuevo León, and El Salto, Durango. The "x" indicates a location near Cushman Reservoir in the Olympic National Forest noted by Don Knutson.

*thobium divaricatum* (a parasite of *Pinus edulis*) from northern Arizona onto *A. americanum* (a parasite of *P. contorta*) in southern Idaho and western Wyoming. Although *C. gillii* was observed in the inoculated areas for 3 years following introduction, it did not become established permanently and Mielke concluded that it did not offer hope for biological control. We consider this study inconclusive, however, because it is possible that a more climatically suitable isolate might have become established. *C. gillii* had not been reported on *A. americanum* at the time of Mielke's study, but it is now known on this dwarf mistletoe in Montana (Gill 1952) and elsewhere. Perhaps more important in this instance than host biotype are the different environments of the two dwarf mistletoes and their host trees. Since *A. divaricatum* grows on *Pinus edulis* in a low-elevation, warm, arid climate, it should not be expected that a fungus associated with it would thrive in the cool, montane *Pinus contorta* forests.

Specimens examined: see Appendix.

#### *Cylindrocarpon* sp.

In Oaxaca in southern Mexico an apparently undescribed *Cylindrocarpon* occurs on *Arceuthobium guatemalense* Hawksw. and Wiens and on *A. rubrum* Hawksw. and Wiens. The fungus is superficially similar to *C. gillii* and causes similar symptoms, but it has much larger spores. Further study, particularly of the fungus in culture, is needed before its taxonomic status can be determined.

#### *Wallrothiella arceuthobii*

This is the first fungus parasite reported on the dwarf mistletoes (Peck 1875). Comprehensive studies of the fungus have been made by Weir (1915), Dowding (1931), Wicker and Shaw (1968), Kuijt (1969), Parker (1970), and Knutson and Hutchins (1974). This fungus is unique in that it parasitizes only the pistillate plants of spring-flowering dwarf mistletoes.

*Wallrothiella arceuthobii* is known on only four dwarf mistletoes; *Arceuthobium pusillum* (Peck 1875) in the East, and three in the West (table 2). It is common on *A. americanum* and *A. douglasii*, but extremely rare on *A. vaginatum* subsp. *cryptopodum* (Hawksworth 1961).

The presently known distribution of *W. arceuthobii* shows a large gap of nearly 700 miles between the northern (Oregon, Washington, Idaho, Montana) and southern (Colorado, Arizona, New Mexico, Mexico) populations (fig. 3). The northwest population occurs principally on *A. douglasii* and occasionally on *A. americanum*. The southern population is known almost exclusively on *A. douglasii* (with the exception of the single collection on *A. vaginatum* subsp. *cryptopodum* from New Mexico). We have searched in many areas within the gap but have failed to discover additional localities. For this reason, and the fact

that we have not found the fungus on dwarf mistletoe herbarium material from anywhere within this region, we suspect the gap is real. Comparative morphological studies of the northern and southern populations should be made.

Infection by *Wallrothiella arceuthobii* is confined to the floral area. The stigma and apical portions of the fruit are replaced with a stroma of the fungus. Normal fruit development is prevented and the affected fruits do not produce seeds. The extent of natural control exerted by *W. arceuthobii* has not been determined. Infection in a given area may be quite variable from year to year. One year's crop may have 90% or more of the fruits destroyed, yet the fungus may be nearly absent in the same locality the following year.

**Specimens examined:** see Appendix.

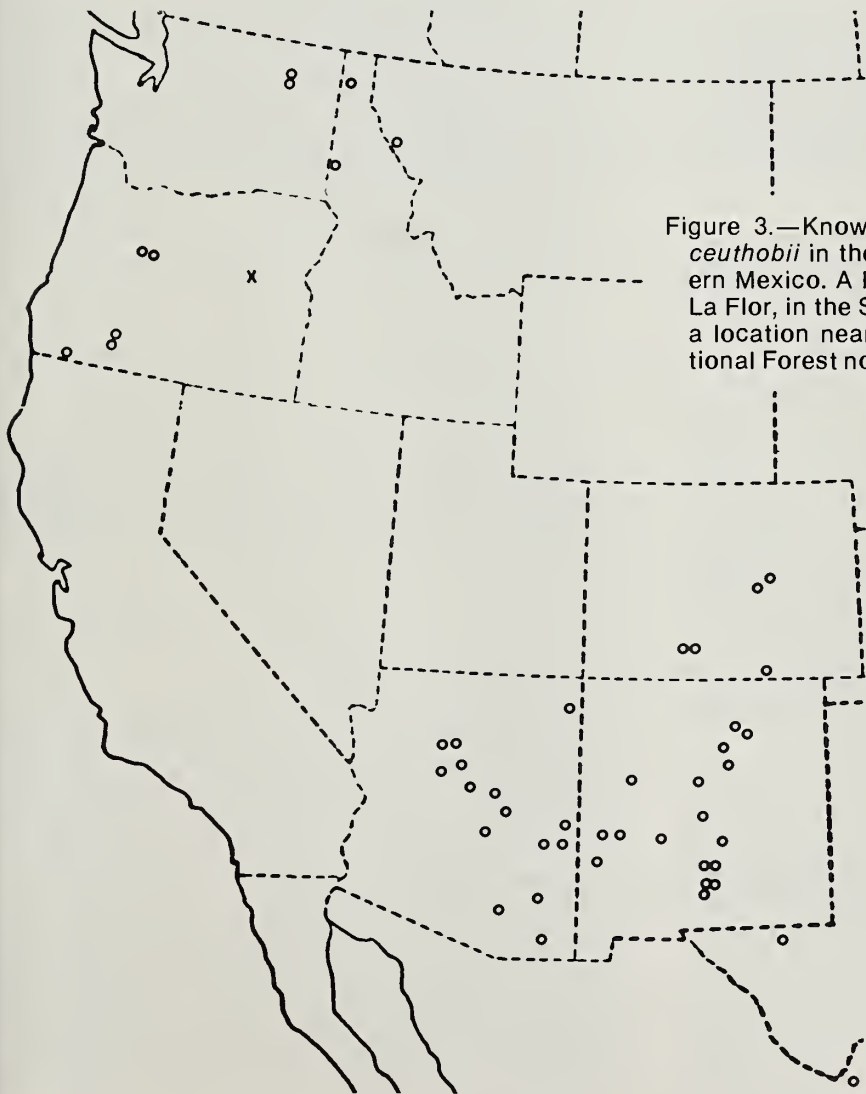


Figure 3.—Known distribution of *Wallrothiella arceuthobii* in the western United States and northern Mexico. A Mexican locality not shown is near La Flor, in the State of Durango. The "x" indicates a location near Crane Prairie in the Malheur National Forest noted by Don Knutson.

## *Alternaria alternata*

The only record of this fungus as a parasite of dwarf mistletoe shoots is by Sutton (1973) who reported it on *Arceuthobium pusillum* Peck on white spruce near Gypsumville, Manitoba, Canada. The fungus develops numerous small, black fruiting bodies over the shoots, particularly at the nodes. *Alternaria alternata* is a ubiquitous fungus that is normally saprophytic or mildly parasitic on a great many plants. In this instance the host tree was apparently weakened, because fruiting bodies of the fungus were common not only on dwarf mistletoe shoots but also on the host spruce branches. The fungus is unknown as a pathogen of dwarf mistletoe shoots in the western United States or Mexico. However, it is one of several canker fungi associated with the resin disease complex of *Arceuthobium americanum* on lodgepole pine in the Rocky Mountains (Mark et al. 1976).

**Specimens examined:** on *Arceuthobium pusillum*, on *Picea glauca*, Amana Bay, 40 miles east of Gypsumville, Manitoba, Canada, collected by D. Shepherd, 1967 (WINF, FPF).<sup>2</sup>

## *Metasphaeria wheeleri*

This fungus is known only from the type collection on *Arceuthobium occidentale* on *Pinus radiata* at Point Lobos, California (Linder 1938). It is reported to infect and kill the shoots of this dwarf mistletoe. Subsequent attempts by W. W. Wagener and R. F. Scharpf to relocate the fungus in this locality and elsewhere in native Monterey pine stands infested with *A. occidentale* have been unsuccessful. The presence of *M. wheeleri* in the type specimen was confirmed, however, by Scharpf in 1969. This fungus is either exceedingly rare or highly sporadic in occurrence in its reported locality. It shows no promise as a biological control agent.

**Specimens examined:** on *Arceuthobium occidentale*, on *Pinus radiata*, Point Lobos, Monterey, California, by L. C. Wheeler (FPB).

## *Pestalotia maculiformans*

The only report of this fungus on dwarf mistletoes is by Wicker and Shaw (1968) who found it

on *Arceuthobium tsugense* near White Pass Summit, Washington. Numerous individual fruiting structures develop subepidermally on infected shoots, and appear as pale yellow flecks. Fruiting bodies may coalesce and assume an irregular shape. As they mature, they erupt irregularly through the cuticle and epidermis of the dwarf mistletoe shoot, exposing the mass of dark colored conidia. Fruiting structures more closely resemble pycnidia than acervuli because they show a greater degree of development than a "cushion-like mass of hyphae having conidiophores and conidia." The hyphae of the fruiting structures form subglobose, hollow fruiting bodies with conidiophores inside (fig. 4).

Since the fungus has not been previously described in *Arceuthobium*, we have prepared the following description: Conidia are fusoid, straight or slightly curved, 5-celled, slightly constricted at septa, 21.5–28.5 by 5.9–8.4  $\mu$  (50 spores); apical cell hyaline, long cylindric, typically supporting 3 setulae; basal cell hyaline, long conic, acute; 3, contrasted colored, intermediate cells, upper 2 umber, lowest olive or pale brown, not swollen across middle, guttulate, walls darker, setulae non-spathulate, hyaline, 15.0–22.5  $\mu$  (50 spores).

Mycelial development within infected shoots is rather sparse, intercellular, and confined to the parenchymatous matrix of the stem. We have observed no hyphae of the fungus to penetrate the vascular tissues.

The dwarf mistletoe shoots in the specimen were already dead at the time of collection. However, inoculations of live dwarf mistletoe shoots with the fungus showed that it is parasitic.

**Specimens examined:** on *Arceuthobium tsugense* (as *A. campylopodum* f. *abietinum*) on *Abies amabilis*, 3 miles west of White Pass, Lewis County, Washington, collected by Ed Wicker, 1962 (WSP 54146).

## *Pestalotia heterocornis*

This fungus (Guba 1961) is reported here for the first time on a dwarf mistletoe. It was found in a collection of *Arceuthobium bicarinatum*, a parasite of *Pinus occidentalis* in the Dominican Republic. Its effects on dwarf mistletoe are not known but apparently minor.

Mycelial development within infected shoots: intercellular, sparse, distributed throughout the parenchymatous matrix and vascular tissues. Initial development of fruiting body a mass of loose, intertwining hyphae; at maturity compact, dark, lenticular, pseudoparenchymatous, punctiform, subepidermal, erumpent, irregularly rupturing

<sup>2</sup>See Appendix for abbreviations of the herbaria cited.

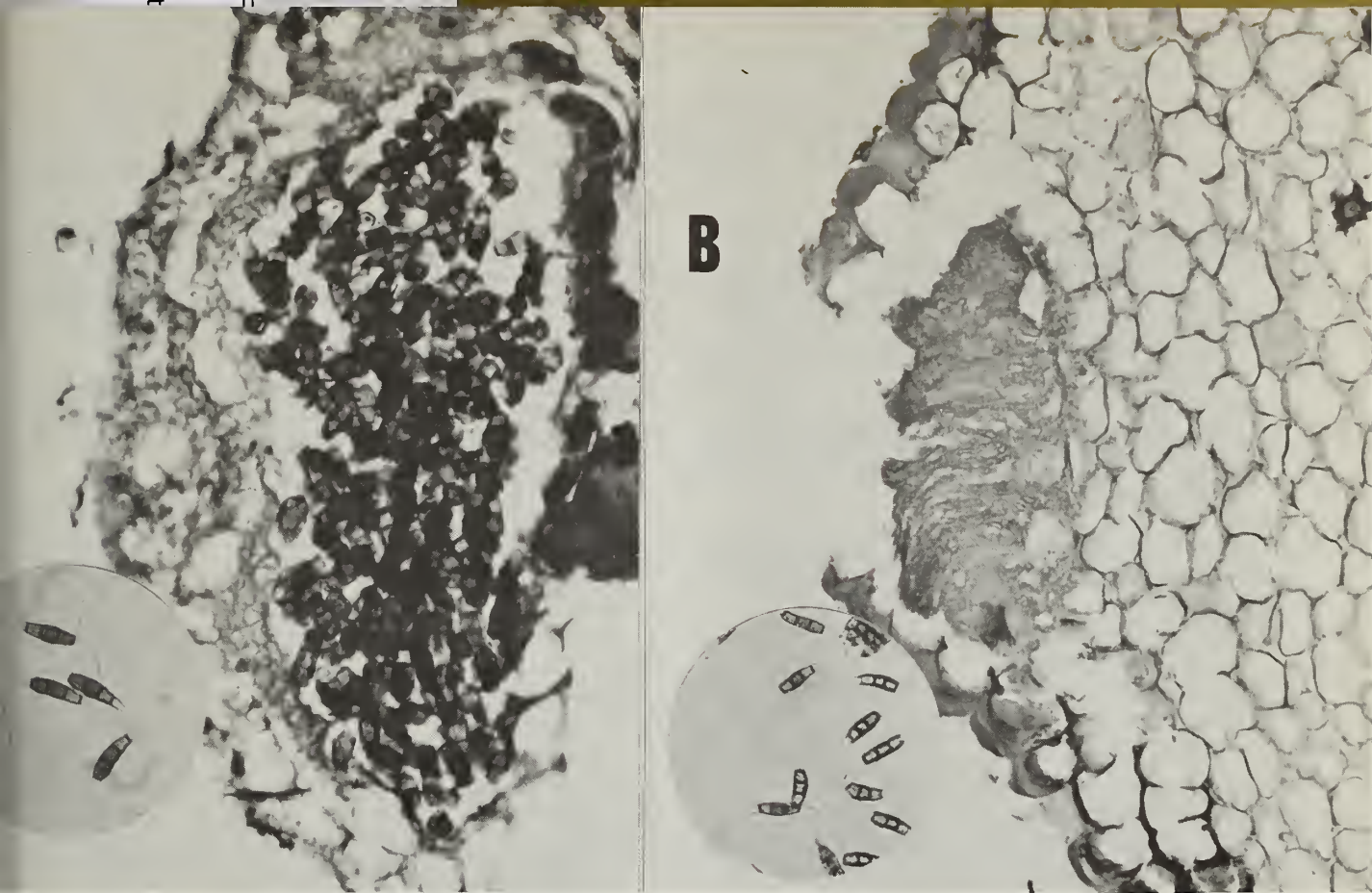


Figure 4.—Fruiting bodies and conidia of 2 species of *Pestalotia* on dwarf mistletoe shoots.

A. *Pestalotia maculiformans* X 325, Conidia X 270.

B. *Pestalotia heterocornis* X 175, Conidia X 270.

the epidermis (fig. 4). Pustules appear as pale yellow flecks on the shoots and often coalesce and assume an irregular shape. Fruiting body more closely resembles an acervulus than a pycnidium.

Description of the fungus: Conidia: narrow fusiform, straight or slightly curved, 5-celled, tapering at extremities, slightly constricted at septa,  $21\text{--}27\ \mu$  by  $5.0\text{--}6.8\ \mu$  (25 spores). Basal cell hyaline, long acute. Apical cell hyaline, long turbinate. Three intermediate colored cells olivaceous-pale brown, concolorous, guttulate, walls darker. Setulae hyaline, 1–3, most commonly 2, unequal in length  $7\text{--}27\ \mu$  long, one stronger, a prolongation of apical cells, attenuated and the other 1 or 2 setulae filliform, subapical, arising along the slope of the apical cell or often irregularly arranged at crest of apical cell, 2–3 joined at crest or sometimes distinct. Pedicels  $3\text{--}8\ \mu$  long.

Specimens examined: on *Arceuthobium bicarinatum* Urban, on *Pinus occidentalis*, Las Canitas, elevation 4,125 ft, Dominican Republic, collected by A. F. Gasbarro, 1963 (FPF 1209).

## CONCLUSIONS

At least eight fungi are known to be parasitic on the shoots of dwarf mistletoes in North America. Three of these (*Colletotrichum gloeosporioides*, *Cylindrocarpon gillii*, and *Wallrothiella arceuthobii*) are common and occur on most of the dwarf mistletoes in the western United States. *Pestalotia heterocornis* and *Cylindrocarpon* sp. are reported for the first time as dwarf mistletoe parasites. The other three fungi (*Pestalotia maculiformans*, *Metasphaeria wheeleri*, and *Alternaria alternata*) are rare or local as dwarf mistletoe parasites. Although *C. gloeosporioides*, *C. gillii*, and *W. arceuthobii* may severely reduce the shoots and seed crops of *Arceuthobium* in certain localities in certain years, their overall role in limiting these parasites seems to be minor. Similarly, since these are native fungi acting on native hosts, the possibilities of their use as biological control agents seem remote.

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## Appendix

Collections examined of the three major dwarf mistletoe hyperparasites.

Abbreviations for herbarium of collections cited are:

**FPB** — Forest Pathology Herbarium, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

**FPF** — Forest Pathology Herbarium, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

**GH** — Gray Herbarium, Harvard University, Cambridge, Mass.

**ILL** — University of Illinois Herbarium, Urbana, Illinois.

**WSP** — Plant Pathology Herbarium, Washington State University, Pullman, Washington.

**WINF** — Forest Pathology Herbarium, Canadian Forest Service, Edmonton, Alberta.

### *Colletotrichum gloeosporioides*

#### *Arceuthobium abietinum*

##### on *Abies concolor*

CALIFORNIA: PLUMAS CO., Grizzly Creek on Oroville-Quincy Road, Scharpf in 1964 (FPB 98106). TUOLUMNE CO., 10 miles S of Long Barn, Scharpf in 1967 (FPB 98131).

##### on *Abies grandis*

OREGON: JEFFERSON CO., 3 miles E of Santiam Pass, Hawksworth and Scharpf 1257 in 1969 (FPF).

##### on *Abies magnifica*

CALIFORNIA: PLUMAS CO., Grizzly Summit on Oroville-Quincy Road, Scharpf in 1964 (FPB 98107).

#### *Arceuthobium americanum*

##### on *Pinus contorta*

CALIFORNIA: PLUMAS CO., 1 mile W of Bucks Lake on Oroville-Quincy Road, Scharpf in 1964 (FPB 98105).

MONTANA: MISSOULA CO., 1 mile SW of Lolo Hot Springs on U.S. 12, Hawksworth and Laut 1290 in 1970 (FPF).

OREGON: JACKSON CO., 5 miles E of Union Creek on Route 62, Hawksworth 1375 in 1971 (FPF).

WASHINGTON: KITTITAS CO., 18 miles N of Teanaway, Wicker in 1966 (WSP 56496, FPF 2459).

#### *Arceuthobium apachecum*

##### on *Pinus strobiformis*

ARIZONA: COCHISE CO., Chiricahua Mts., Mielke and Ellis in 1944 (FPF 89697).

#### *Arceuthobium californicum*

##### on *Pinus lambertiana*

CALIFORNIA: PLUMAS CO., Fananin Meadows—Butte Creek, near Lake Almanor, Scharpf in 1971 (FPB 98605).

#### *Arceuthobium campylopodum*

##### on *Pinus attenuata*

CALIFORNIA: SISKIYOU CO., McCloud, Scharpf in 1965 (FPB 98113).

##### on *Pinus jeffreyi*

CALIFORNIA: ELDORADO CO., Placerville, Hawksworth 1319 in 1971 (FPF). SHASTA CO., Burney Falls, Scharpf in 1965 (FPB 98114).

**on *Pinus ponderosa***

CALIFORNIA: SISKIYOU CO., McCloud, Scharpf in 1965 (FPB 98111).

IDAHO: KOTENAI CO., Coeur d'Alene, Weir 9866 in 1915 (ILL).

OREGON: WHEELER CO., 26 miles S of Hardmann, Hawksworth and Scharpf 1271 in 1969 (FPF) (FPB 98656).

WASHINGTON: SPOKANE CO., Spokane, Weir 8475 in 1917 (ILL); 3 miles N of Spangle, Wicker in 1963 (WSP 54002, WSP 51932).

***Arceuthobium divaricatum***

**on *Pinus edulis***

ARIZONA: APACHE CO., Canyon de Chelly Natl. Mon., Lightle et al. in 1965 (FPF 2150). Sawmill, Lightle and Weiss in 1966 (FPF 2498). COCONINO CO., Grand Canyon Natl. Park, South Rim, Hawksworth in 1954 (FPF 1760); Long Valley, Ellis in 1939 (FPF 89426); Jacob Lake, Ellis in 1939 (FPF 89419). MOHAVE CO., Grand Canyon Natl. Mon., 6 miles S of Mt. Trumbull, Hawksworth 1165 in 1969 (FPF).

COLORADO: MONTEZUMA CO., North Entrance, Mesa Verde Natl. Park, Scharpf and Hawksworth in 1964 (FPB 98108, FPF 1727); 2 miles E of Cortez, Wicker in 1967 (WSP 57618).

NEW MEXICO: CATRON CO., 8 miles SE of Apache Creek, Lightle in 1965 (FPF 2154).

LINCOLN CO., Gallinas Mts., Hawksworth 1078 in 1967 (FPF). SANDOVAL CO., 14 miles NW of Cuba, Hawksworth and Scharpf 692 in 1964 (FPF). TAOS CO., 12 miles S of Tres Piedras, Hawksworth 1011 in 1967 (FPF).

UTAH: KANE CO., Glendale, Wiens 3179 in 1962 (FPF).

**on *Pinus quadrifolia***

MEXICO: BAJA CALIFORNIA, Sierra Juarez, Scharpf and Hawksworth in 1965 (FPB 98110, FPF 1948).

***Arceuthobium douglasii***

**on *Pseudotsuga menziesii***

IDAHO: LATAH CO., 3 miles E of Viola, Wicker in 1963 (WSP 54005).

WASHINGTON: FERRY CO., Growden, Wicker in 1963 (WSP 51931); Lane Creek, Wicker in 1964 (WSP 54006) and in 1966 (WSP 56495). YAKIMA CO., Tieton Reservoir, Wicker in 1963 (WSP 54007).

***Arceuthobium laricis***

**on *Larix occidentalis***

IDAHO: IDAHO CO., 28 miles W of Lolo Pass on U.S. 12, Hawksworth 1292 in 1970 (FPF).

OREGON: JEFFERSON CO., 2 miles W of Camp Sherman, Hawksworth and Scharpf 1258 in 1969 (FPF, FPB 98655).

WASHINGTON: FERRY CO., Growden, Wicker in 1962 (WSP 52723) and 1963 (WSP 54004) and 1964 (WSP 54003).

***Arceuthobium microcarpum***

**on *Picea pungens***

ARIZONA: APACHE CO., 5 miles SW of Alpine, Scharpf and Hawksworth in 1964 (FPB 98109, FPF 1736); 10 miles E of McNary, Hawksworth 1083 in 1967 (FPF). GREENLEE CO., Hannagan Meadows, Hawksworth 1082 in 1968 (FPF).

***Arceuthobium occidentale***

**on *Pinus sabiniana***

CALIFORNIA: CONTRA COSTA CO., Mt. Diablo State Park, Scharpf in 1959 (FPB 98712). NAPA CO., Middletown, Scharpf in 1965 (FPB 98112).

***Arceuthobium tsugense***

**on *Tsuga mertensiana***

CALIFORNIA: SISKIYOU CO., Marble Mts., Chimney Rock Lake, Hemphill in 1968 (FPF 2812).

## *Cylindrocarpon gillii*

### *Arceuthobium abietinum*

#### on *Abies concolor*

ARIZONA: COCONINO CO., Grand Canyon Natl. Park, North Rim, *Gill and Ellis* 1939 (FPF 89417) and *Hawksworth* 252 and 254 in 1962 (FPF).

CALIFORNIA: ALPINE CO., 8 miles SW of Silver Creek, *Hawksworth and Scharpf* 667 in 1964 (FPF). DEL NORTE CO., just S of Calif. line on O'Brien-Happy Camp Rd., *Hawksworth and Hinds* 999 in 1966 (FPF). SAN BERNARDINO CO., Camp Angelus, *Wiens* 3210 in 1962 (FPF). SHASTA CO., Lassen Natl. Park, 4 miles N of N entrance, *Hawksworth and Wiens* 648 in 1964 (FPF). SISKIYOU CO., Mt. Shasta, *Hawksworth and Wiens* 641 in 1964 (FPF); Joe Creek, 10 miles S of Copper, Oregon, *Hawksworth and Wiens* 635 in 1964 (FPF).

NEVADA: CLARK CO., Charleston Mts., *Scharpf and Hawksworth* in 1964 (FPB 98123); *Clokey* 5433 in 1935 (FPF).

OREGON: KLAMATH CO., 9 miles N of Ft. Klamath on Route 62, *Hawksworth* 1377 in 1971 (FPF); 31 miles W of Klamath Falls, *Hawksworth and Wiens* 629 in 1964 (FPF).

LAKE CO., 8 miles SW of Beatty, *Hawksworth and Wiens* 874 in 1966 (FPF); 12 miles SW of Silver Lake, *Stewart* in 1968 (FPF).

UTAH: KANE CO., 8 miles S of Navajo Lake, *Wiens* 4122 in 1966 (FPF).

#### on *Abies grandis*

CALIFORNIA: SISKIYOU CO., near Oregon border on O'Brien-Happy Camp Rd., *Hawksworth and Hinds* 998 in 1966 (FPF).

OREGON: DESCHUTES CO., Squaw Creek south of Sisters, *Fender* in 1974 (FPF).

#### on *Abies magnifica*

CALIFORNIA: CALAVERAS CO., 8 miles SW of Tamarack, *Hawksworth and Scharpf* 663 in 1964 (FPF). FRESNO CO., Huntington Lake, *Miller* in 1965 (FPB 98117). SHASTA CO., 10 miles N of North entrance to Lassen Natl. Park, *Hawksworth and Wiens* 650 in 1964 (FPF). TUOLUMNE CO., Pinecrest, *Scharpf* in 1963 (FPF 1416) and 1965 (FPB 98122); Yosemite Natl. Park, 7 miles E of Crane Flat, *Hawksworth* 938 in 1966 (FPF).

### *Arceuthobium americanum*

#### on *Pinus contorta*

CALIFORNIA: CALAVERAS CO., 3 miles SW of Tamarack, *Hawksworth and Scharpf* 664 in 1964 (FPF).

COLORADO: GRAND CO., 18 miles S of Parshall, *Hawksworth and Hinds* in 1960 (FPF 1419). JACKSON CO., 8 miles NE of Cowdry, *Davidson and Gill* in 1952 (FPF 89991); Pearl, ca 20 miles NW of Cowdry, *Hawksworth* 830 in 1965 (FPF); 10 miles NE of Cowdry, *Hawksworth* 942 in 1966 (FPF); 2 miles N of Gould, *Hawksworth* 1091 in 1968 (FPF). SUMMIT CO., Dillon, *Hawksworth* 1640 in 1975 (FPF).

MONTANA: MEAGHER CO., Little Belt Mts., 16 miles N of White Sulfur Springs, *Gill* in 1948 (FPF 89984).

WYOMING: ALBANY CO., Pelton Creek, 4 miles W of Mountain Home, *Hawksworth* 1092 in 1968 (FPF). FREMONT CO., Green Mts., *Hawksworth* 1691 in 1976 (FPF).

### *Arceuthobium apachecum*

#### on *Pinus strobiformis*

ARIZONA: APACHE CO., 4 miles S of Eagar, *Hawksworth and Lightle* 210 in 1962 (FPF). COCHISE CO., Chiricahua Mts., *Ellis and Gill* in 1939 (FPF 89404); *Ellis* in 1939 (FPF 89423); *Gill and Ellis* in 1940 (FPF 89432); *Mielke and Ellis* in 1944 (FPF 89695). GRAHAM CO., Graham Mts., *Stouffer and Gill* in 1934 (FPF 68292 and 68293); *Gill* in 1936 (FPF 89313); *Ellis* in 1938 (FPF 89401) and 1939 (FPF 89431, 89415 and 89429); *Mielke and Ellis* in 1944 (FPF 89693). GREENLEE CO., Blue Summit, *Ellis* in 1939 (FPF 89413). PIMA CO., Santa Catalina Mts., *Ellis* in 1939 (FPF 89424); *Gill and Ellis* in 1939 (FPF 89407); *Mielke and Ellis* in 1944 (FPF 89696).

NEW MEXICO: CATRON CO., 7 miles E of Mogollon, *Hawksworth and Lightle* 929 in 1966 (FPF). SOCORRO CO., Magdalena Mts., North Baldy Mt., *Lightle* in 1966 (FPF 2491); San Mateo Mts., *Hawksworth and Lightle* 1117 in 1968 (FPF).

## *Arceuthobium blumeri*

### on *Pinus strobiformis*

ARIZONA: SANTA CRUZ CO., Santa Rita Mts., Mt. Wrightson, *Hawksworth* 796 in 1965 (FPF).

MEXICO: DURANGO, 19 miles W of Santiago Papasquiaro, *Hawksworth and Wiens* 536 in 1963 (FPF). NUEVO LEON., Cerro Potosi, *Hawksworth and Wiens* 392 in 1963 (FPF).

## *Arceuthobium californicum*

### on *Pinus lambertiana*

CALIFORNIA: PLUMAS CO., 5 miles W of Quincy, *Hawksworth and Wiens* 654 in 1964 (FPF). NEVADA CO., Graniteville, *Boyce* in 1917 (FPF 1501).

### on *Pinus monticola*

CALIFORNIA: SISKIYOU CO., High Creek Camp, Mt. Eddy, *Scharpf* in 1965 (FPB 98115).

OREGON: COUNTY UNCERTAIN, between Ashland and Klamath Falls, *Weir* 3239 in 1916 (FPF). CURRY CO., Saddle Mt., *Bynum* in 1967 (FPF 2638).

## *Arceuthobium campylopodum*

### on *Pinus attenuata*

OREGON: JOSEPHINE CO., Oregon Mtn., *Howard* in 1964 (FPF 2369).

### on *Pinus coulteri*

CALIFORNIA: LOS ANGELES CO., Mt. Wilson, *Perkins* in 1919 (ILL).

### on *Pinus jeffreyi*

CALIFORNIA: ALPINE CO., 1 mile S of Markelville, *Hawksworth* 1303 in 1970 (FPF). LOS ANGELES CO., Big Pines, *Hawksworth* 728 in 1965 (FPF). SHASTA CO., Manzaniza Chute, *Scharpf* in 1965 (FPB 98118). TOULUMNE CO., Longbarn, *Thomas* 5519 in 1963 (FPF).

OREGON: JOSEPHINE CO., Wonder, *Mitchell* in 1932 (FPF 68212).

### on *Pinus ponderosa*

CALIFORNIA: CALAVERAS CO., 15 miles SW of Tamarack, *Hawksworth and Scharpf*

661 in 1964 (FPF). KERN CO., Greenhorn Mts., Tiger Flat, *Wiens* 3607 in 1964 (FPF). TOULUMNE CO., Longbarn, *Wright* in 1932 (FPF 68117).

IDAHO: KOOTENAI CO., Coeur d'Alene Lake, *Wicker* in 1973 (FPF 3212).

NEVADA: CLARK CO., Charleston Mts., Kyle Canyon, *Hawksworth and Scharpf* 675 in 1964 (FPF).

OREGON: DESCHUTES CO., Pringle Falls Exp. Forest, *Wicker* in 1966 (WSP 56492) and *Hawksworth* 989 in 1966 (FPF); Squaw Creek south of Sisters, *Knutson* in 1974 (FPF). GRANT CO., Lee Creek, 25 miles ESE of Seneca, *Hawksworth and Scharpf* 1267 in 1969 (FPF).

WASHINGTON: SPOKANE CO., 3 miles N of Spangle, *Wicker* in 1962 (WSP 52733).

YAKIMA CO., Tieton Canyon, *Wicker* in 1962 (WSP 52730) and in 1964 (WSP 54012).

## *Arceuthobium cyanocarpum*

### on *Pinus flexilis*

UTAH: GARFIELD CO., Bryce Canyon Natl. Park, *Gill* in 1932 (FPF 68144).

### on *Pinus monticola*

CALIFORNIA: TRINITY CO., Mt. Eddy, *Scharpf* in 1965 (FPB 98115) and *Miller and Bynum* in 1964 (FPF 1768).

## *Arceuthobium divaricatum*

### on *Pinus edulis*

ARIZONA: APACHE CO., 8 miles SW of Red Rock, *Lightle and Weiss* in 1966 (FPF 2504). COCONINO CO., Grand Canyon Natl. Park, South Rim, *Hawksworth and Scharpf* 701 in 1964 (FPF) and *Hawksworth* 1088 in 1967 (FPF). Jacob Lake, *Ellis* in 1939 (FPF 89419); *Mielke* in 1944 (FPF 89700), and *Hawksworth and Gill* in 1952 (FPF 89990). 34 miles S of Winslow on Chevelon Rd., *Hawksworth and Lightle* 916 in 1966 (FPF). NEW MEXICO: BERNALILLO CO., Sandia Mts., *Ellis* in 1939 (FPF 89411). LINCOLN CO., Nogal, *Hawksworth and Lightle* 101 in 1962 (FPF).

UTAH: GARFIELD CO., Table Cliffs, *Peterson* 64-87 in 1964 (FPF).

**on *Pinus monophylla***

CALIFORNIA: KERN CO., 31 miles SE of Maricopa, *Wiens* 3217 in 1962 (FPF). MONO CO., 5 miles S of Walker on Rt. 395, *Scharpf* in 1970 (FPB 98713).

***Arceuthobium douglasii***

**on *Pseudotsuga menziesii***

ARIZONA: GRAHAM CO., Graham Mts., *Ellis* in 1939 (FPF 89427) and *Mielke and Ellis* in 1944 (FPF 89698). PIMA CO., Santa Catalina Mts., *Ellis* in 1939 (FPF 89425) and *Gill and Ellis* in 1939 (FPF 89406).

***Arceuthobium laricis***

**on *Larix occidentalis***

WASHINGTON: YAKIMA CO., 5 miles E of White Pass, *Wicker* in 1962 (WSP 52731, 52734) and in 1964 (WSP 54011).

***Arceuthobium microcarpum***

**on *Picea engelmannii***

ARIZONA: APACHE CO., 20 miles W of Eagar, *Hawksworth and Lightle* 207 in 1962 (FPF); 2 miles E of Big Lake, *Hawksworth* 1285 in 1970 (FPF). COCONINO CO., Grand Canyon Natl. Park, North Rim, *Gill and Ellis* in 1939 (FPF 89418), and *Wicker* in 1967 (WSP 57619). GRAHAM CO., Graham Mts., *Gill* in 1934 (FPF 68310 and 68240); *Ellis* in 1938 (FPF 89402); *Ellis* in 1939 (FPF 89414

and 89428); *Ellis* in 1940 (FPF 89433); *Mielke and Ellis* in 1944 (FPF 89692). GREENLEE CO., Hannagan Meadows, *Lightle* in 1964 (FPF 1794); Blue Summit, *Ellis* in 1939 (FPF 89412).

**on *Picea pungens***

ARIZONA: APACHE CO., 2 miles SW of Greer, *Hawksworth and Lightle* 925 in 1966 (FPF).

***Arceuthobium tsugense***

**on *Abies amabilis***

WASHINGTON: LEWIS CO., 3 miles W of White Pass, *Wicker* in 1961 (WSP 52111), in 1962 (WSP 52732, 54008), in 1963 (WSP 54009), and 1966 (FPF 2467).

**on *Pinus albicaulis***

OREGON: DESCHUTES CO., 1 mile E of McKenzie Pass, *Knutson* in 1976 (FPF).

**on *Tsuga heterophylla***

OREGON: BENTON CO., Marys Peak, *Knutson* in 1973 (FPF). LINN CO., Sheep Creek on Highway 20, *Knutson* in 1973 (FPF).

WASHINGTON: PIERCE CO., Longmire, *Gill* in 1932 (FPF 68199). YAKIMA CO., 3 miles W of White Pass, *Wicker* in 1962 (WSP 52736, 54001) in 1963 (WSP 54010), and in 1966 (FPF 2466).

**on *Tsuga mertensiana***

CALIFORNIA: ALPINE CO., Ebbetts Pass, *Hawksworth and Scharpf* 665 in 1964 (FPF). SISKIYOU CO., Marble Mts., Kidder Creek, *Gill and Sargent* in 1932 (FPF 68180).

OREGON: JACKSON CO., 10 miles NE of Prospect, *Graham* in 1965 (FPF 2335).

***Wallrothiella arceuthobii***

***Arceuthobium americanum***

**on *Pinus contorta***

IDAHO: BONNER CO., Priest Lake, *Piper* 3701 in 1901 (GH).

MONTANA: MINERAL CO., 6 miles W of St. Regis, *Hawksworth and Wicker* 954 in 1966 (FPF).

OREGON: LINN CO., Junction of Highways 20 and 22, near Santiam Pass, *Knutson* in 1976 (FPF).

WASHINGTON: FERRY CO., Growden, *Wicker* in 1961 (WSP 52158) and 1962 (WSP 52735).

***Arceuthobium douglasii***

**on *Pseudotsuga menziesii***

ARIZONA: APACHE CO., 5 miles SW of Alpine, *Lightle* in 1964 (FPF 1793) and

*Hawksworth and Scharpf* 699 in 1964 (FPF). 3 miles NW of Maverick, *Hawksworth and Lightle* 902 in 1966 (FPF). COCHISE CO., Chiricahua Mts., *Gill and Ellis* in 1935 (FPF 68056); *Gill and Ellis* in 1939 (FPF 89497 and 89408). COCONINO CO., Oak Creek Canyon, *Ellis* in 1939 (FPF 89504); Baker Butte, *Andrews et al.* in 1932 (FPF 89229); 3 miles E of Long Valley, *Lightle* in 1964 (FPF 1791); Rim Road 5 miles E of Sitgreaves Natl. For. boundary, *Lightle* in 1964 (FPF 1792); Mormon Lake, *Hawksworth and Lightle* 913 in 1966 (FPF); 11 miles S of Chevelon R.S., *Hawksworth and Lightle* 918 in 1966 (FPF). GILA CO., Sierra Ancha Expt. For., *Hawksworth* 44 in 1954 (FPF). GRAHAM CO., Graham Mts., *Stouffer* in 1934 (FPF 68289); *Stouffer and Gill* in 1934 (FPF 68294); *Ellis* in 1938 (FPF 89403); *Ellis* in 1939 (FPF 89427), *Mielke and Ellis* in 1944 (FPF 89694 and 89698); *Hawksworth and Lightle* 226 in 1962 (FPF). GREENLEE CO., 47 miles S of Springerville on US 666, *Gill* in 1934 (FPF 68303). NAVAJO CO., Rim Road, 6 miles E of Rt 160, *Hawksworth and Lightle* 920 in 1966 (FPF). PIMA CO., Santa Catalina Mts., *Gill and Ellis* in 1939 (FPF 89406 and 89501); *Gill* in 1932 (FPF 68125). COLORADO: EL PASO CO., No. Cheyenne Canyon, *Hawksworth* 538 in 1963 (FPF). FREMONT CO., Phantom Canyon, 13 miles S of Victor, *Hawksworth and Laut* 1335 in 1971 (FPF). HINSDALE CO., 21 miles NW of Pagosa Springs, *Landgraf* in 1965 (FPF 1997). LAS ANIMAS CO., 12 miles S of Stonewall Gap, *Hawksworth and Laut* 1331 in 1971 (FPF). MINERAL CO., 7 miles W of Wolf Creek Pass, *Hawksworth and Mathiasen* 1451 in 1973 (FPF). IDAHO: LATAH CO., 3 miles E of Viola, *Wicker* in 1959 (WSP 47614). NEW MEXICO: BERNALILLO CO., Sandia Mts., *Long and Seay* in 1916 (FPF 21275); *Ellis* in 1939 (FPF 89505). CATRON CO., Mangas Mt., *Scharpf and Hawksworth* in 1964 (FPB 98116, FPF 1733); Fox Mt., *Hawksworth and Lightle* 928 in 1966 (FPF); Bearwallow Mt., *Hawksworth and Lightle* 898 in 1966 (FPF). COLFAX CO., 8 miles SE of Black Lake, *Lightle* in 1965 (FPF 2134).

LINCOLN CO., Capitan Mts., W. Capitan Mt., *Lightle* in 1966 (FPF 2490); Gallinas Mts., *Lightle and Riffle* in 1963 (FPF 1412) and *Hawksworth* 1079 in 1967 (FPF); Capitan Mts., Capitan Gap, *Hawksworth and Lightle* 1099 in 1968 (FPF). OTERO CO., 7 miles E of Cloudcroft, *Hawksworth* 1 in 1967 (FPF); Mescalero Apache Reservation; Goat Canyon, *Hawksworth* in 1952 (FPF 89992); Summit Canyon *Hawksworth* 26 in 1952 (FPF) and *Hawksworth and Scharpf* 694 in 1964 (FPF, FPB 98120). SAN JUAN CO., 6 miles SW of Sheep Springs, *Lightle and Weiss* in 1966 (FPF 2496). SAN MIGUEL CO., 15 miles E of Pecos, *Lightle* in 1963 (FPF 1308); Cowles, *Lightle* in 1965 (FPF 2129 and 2130). SOCORRO CO., San Mateo Mts., *Long* in 1915 (FPF 21126). TAOS CO., 1 mile W of Colfax Co. on US 64, *Lightle* in 1965 (FPF 2126). TORRANCE CO., 3 miles NW of Manzano, *Riffle* in 1963 (FPF 1208). VALENCIA CO., Mt. Sedgwick, *Lightle* in 1965 (FPF 1790).

OREGON: JACKSON CO., 9 miles NE of Prospect, *Graham* in 1965 (FPF 2357); 10 miles E of Butte Falls, *Graham* in 1964 (FPF 1703); 12 miles SE of Butte Falls, *Graham* in 1965 (FPF 2356). JEFFERSON CO., Suttle Lake, *Knutson* in 1976 (FPF). JOSEPHINE CO., 13 miles E of O'Brien, *Hawksworth and Hinds* 997 in 1966 (FPF).

TEXAS: CULBERSON CO., Guadalupe Mts. Natl. Park, The Bowl, *Hawksworth and Bailey* 1528 in 1975 (FPF).

WASHINGTON: FERRY CO., Lane Creek, *Wicker* in 1966 (WSP 56491).

MEXICO: COAHUILA, Sierra del Carmen, *Hawksworth and Lightle* 1027 in 1967 (FPF).

DURANGO: 47 miles S of Durango on La Flor Road, *Hawksworth and Wiens* 514 in 1963 (FPF).

### *Arceuthobium vaginatum* subsp. *cryptopodum*

#### on *Pinus ponderosa*

NEW MEXICO: OTERO CO., Mescalero Apache Reservation, Goat Canyon, *Hawksworth* in 1952 (FPF 98511).

Hawksworth, Frank G., Ed F. Wicker, and Robert F. Scharpf. 1977. Fungal parasites of dwarf mistletoes. USDA For. Serv. Gen. Tech. Rep. RM-36, 14 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 80521.

At least eight fungi are known to parasitize dwarf mistletoe shoots in North America. Three of these (*Colletotrichum gloeosporioides*, *Cylindrocarpon gillii*, and *Wallothiella arceuthobii*) are common and occur on most of the dwarf mistletoes in the western United States. *Pestalotia heterocornis* and *Cylindrocarpon* sp. are reported for the first time as dwarf mistletoe parasites. Although some of these fungi may decimate dwarf mistletoe shoots and fruits in certain localities in certain years, their overall role in limiting dwarf mistletoes seems to be minor.

**Keywords:** *Colletotrichum gloeosporioides*, *Cylindrocarpon gillii*, *Wallothiella arceuthobii*, hyperparasites, biological control.

Hawksworth, Frank G., Ed F. Wicker, and Robert F. Scharpf. 1977. Fungal parasites of dwarf mistletoes. USDA For. Serv. Gen. Tech. Rep. RM-36, 14 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 80521.

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